

UNCLASSIFIED

AD NUMBER

AD039440

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; APR 1954. Other requests shall be referred to Air Force Holloman Air Development Center, Holloman AFB, NM.

AUTHORITY

DAF Memorandum dtd 24 Mar 1997

THIS PAGE IS UNCLASSIFIED

Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

AD

39440

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by
DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO

UNCLASSIFIED

AD NO. 39440

ASTIA FILE COPY

4

54

TN

HADC

11

HADC TN-54-4

DEVELOPMENT OF SHROUD INFLATION TECHNIQUES
FOR PLASTIC BALLOONS

by

BERNARD D. CILDENBERG



HOLLOMAN AIR FORCE BASE

NEW MEXICO APRIL 1954

HOLLOMAN AIR DEVELOPMENT CENTER

DEVELOPMENT OF SHROUD INFLATION TECHNIQUES
FOR PLASTIC BALLOONS

PREPARED BY:



BERNARD D. GILDENBERG
Chief, Technical Staff
Balloon Unit
6580th Test Squadron (Sp)

REVIEWED BY:



HENRY J. STUART
Chief, Technical Operations
6580th Test Squadron (Sp)

APPROVED BY:



WILBUR D. PRITCHARD
Lt Col, USAF
Commander, 6580th Test Squadron (Sp)

REPORT NO. HADC-TN-54-4

COPY NO. 11

HOLLOMAN AIR FORCE BASE, NEW MEXICO

APRIL 1954

ABSTRACT

The problem of handling vertical inflations of polyethylene balloons, grossing 1,500 or more pounds, was thoroughly investigated at Holloman Air Development Center in May 1953. The status of the problem prior to the investigation is discussed. A shroud cap was developed as the primary solution to the problem. Becoming an operational feature by September 1953, the cap has increased inflation capabilities from 2 to at least 7 knots of surface winds. The resulting increase in the number of possible launching days is highly indicative. The basic shroud cap technique has been solidified and modifications are being pursued to increase its versatility.

PUBLICATION REVIEW

Manuscript copy of this report has been reviewed and approved for publication.

FOR THE COMMANDER:

for Anthony J. Elder
CLARENCE L. ELDER
Colonel, USAF
DCS/Operations

TABLE OF CONTENTS

	Page No.
I. PURPOSE	1
II. FACTUAL DATA	1 - 11
A. Introduction	1 - 4
B. Design of Shroud	4 - 7
C. Description of Tests	8 - 9
D. Evolution of the Shroud Cap Release System	9 - 11
III. DISCUSSION OF RESULTS	11 - 12
A. Test Summary	11
B. Comparison with Other Launching Systems	11 - 12
IV. CONCLUSIONS	12 - 13
V. RECOMMENDATIONS	13
SUMMARY OF TESTS WITH SHROUD CAP NO. 1	14
APPENDIX I	15 - 16
APPENDIX II	17

LIST OF ILLUSTRATIONS

(Following Page 17)

Figure 1. Shroud Cap Techniques, 3/4 Million Cubic Foot Balloon

Figure 2. Forked Hold-Down Lines

Figure 3. Hold-Down Lineman

Figure 4. Reefer Tied to Cap Perimeter

Figure 5. Test No. 1, With Dummy Canvas Shroud

Figure 6. First Shroud Release Method

Figure 7. (Page 10)

Figure 8. Lacing on Shroud Cap

Figure 9. 800 Pound Load, Launched in 7 Knot Wind on a 92.5 Ft. Diameter Balloon

Figure 10. (A-h). Shroud Inflation, Step by Step

DEVELOPMENT OF SHROUD INFLATION TECHNIQUES FOR PLASTIC BALLOONS

I. PURPOSE

In May 1953, personnel of the Balloon Unit assembled for a series of discussions with the objective of selecting methods to improve the vertical inflation methods for large plastic balloons. This action appeared necessary because of the advent of new projects with payloads in the half-ton order of magnitude and the increased demands of contractors for the use of the 3/4 million cubic foot balloon. At that time the vertical inflation techniques employed were limited to surface winds of 2 knots or less. The number of possible launching days, consequently, was greatly restricted. In addition, the occurrence of a single gust of large magnitude during a relatively calm inflation period could be disastrous.

As a result of these discussions, the shroud inflation technique was developed at Holloman Air Development Center, becoming operational on 16 September 1953.

II. FACTUAL DATA

A. Introduction:

1. The specific authority for the development of this shroud system technique is found under Stage 1 of the Test Directive No. 5182-H1. It requests the "development of dependable and safe launching and lifting techniques for plastic balloons which are capable of carrying loads of 1,000 pounds to altitudes between 50,000 and 100,000 feet, MSL.

The continued success of this system in the operational form, however, has already resulted in its adaption at Holloman Air Development Center for all heavy load balloon programs, including cells up to 116 feet in diameter (See Figure 1).

2. Status of the Problem Prior to the Present Investigation:

The earliest vertical inflation techniques for plastic balloons, originating in the Fall of 1946, involved no special equipment. The balloons were from 7 to 20 feet in diameter and usually inflated in hangars. They were simply layed out on a ground cloth and walked up to a vertical position as the lifting gas was applied. After the inflation was completed and the payload attached, the cell was walked out of the down-wind side. The actual release was negotiated at some distance away from the hangar where the top of the balloon was first affected by wind eddies. In a relatively light wind this might be some 30 or 50 feet despite allowing for a good safety margin in the case of eddies sweeping back toward the hangar.

This "primitive" technique became less and less frequent as larger balloons and payloads limited the system to the few largest hangars

in the country. Notwithstanding monetary and geographical complications, however, this earliest of vertical inflation systems may represent the ultimate.

As the number of plastic balloon launching sites increased, this basic vertical inflation system was of necessity applied completely outdoors. Large buildings and the first formal wind screens were employed as shelter from surface winds.

The first appendages for vertical inflations were developed by the General Mills' Balloon group in 1950. The most important of these was the reefing sleeve. Constructed of polyethylene, it extended from the base of the gas bubble down to the balloon appendix. The configuration was a cylinder which was used to restrict the gas within the cell to a tight bubble, thus minimizing the sailing of the balloon because of the wind. As more gas was fed into the balloon, the sleeve was pulled gradually downward to prevent too much pressure at the base of the bubble. The reefing sleeve evolved from the launch platform technique, the launch arms representing the top of the sleeve. In a launch platform inflation, before the bubble becomes vertical, the ground cloth is often used as a pseudo-reefing sleeve.

The second most important vertical inflation modification applied by General Mills, was the use of hold-down lines. The latter were tied into tapes near the maximum balloon diameter. The function of these lines was to prevent the twisting of the balloon, which occurred in surface winds when the balloon was in the vertical position. The twisting effect menaced the inflation by causing the inflation tube to twist and restricted the passage of the gas. The twisting problem is the largest initial barrier for any vertical inflation system.

The Holloman Air Development Center Balloon Unit did not encounter the vertical inflation problem until it was assigned some flights for Project Gopher. On 24 September 1952, a vertical inflation attempt was made with a 896-pound load. The only appendage was a simple polyethylene reefing sleeve. The inflation was successful, although it could be seen that nothing much more than a perfect calm could be tolerated during the process.

On the second flight, 2 October, three innovations were devised:

- (1) The balloon was inflated while tied into a C-2 wrecker boom. This made it easier to work around the balloon during inflation, allowed the payload to be worked on during inflation, prevented damage to the payload in the event of a hold-down line failure and allowed the balloon to be moved during inflation, if necessary.
- (2) A canvas reefing cloth, which could be used over and over again, was employed. It could be unbuckled as it was reefed off the balloon down to the ground.
- (3) A special heavy test swivel was tied in between the boom and the balloon load ring in an attempt to compensate for the twisting effect.

The first innovation has been used successfully ever since. The idea of a permanent reefer has been retained, although the form has been modified. The swivel appears to be ineffective.

With these two successful modifications, a total of seven vertical inflations were performed for Project Gopher with loads varying from 500 to 900 pounds.

Four months after the last of these flights (May 1953), the first balloons for TD No. 5102-III arrived. The boom and the canvas reefer combination was at this time known to be reliable in a wind of not more than 2 knots.

The significant increase in frequency of vertical inflations dictated by this new program would not tolerate a 2 knot launching wind limitation. With this fact in mind, the Balloon Unit at Holloman Air Development Center selected the quickest possible solution (the balloon modified hold-down system employed by General Mills) for field tests. The 72.8-foot diameter balloons, already modified with 4 "D" rings at the equator, were on hand and tests were made that month. Hold-down lines were tied to the "D" rings in an effort to control twisting. The results indicated the system was capable of increasing the inflation capabilities to 4 knots. The advantage did not seem significant, especially when considering the possible damage inflicted to the balloon by stresses applied at the cell's equator by the hold-down lines.

At the conclusion of these tests, discussions were held which led to the design of the shroud cap.

3. Previous Shroud Techniques:

The shroud inflation system is not new for balloons other than the present giant polyethylene cells. The majority of the manned and unmanned non-extensible balloons prior to the Twentieth Century employed shroud nets. In fact, the first positively identified balloon flight (unmanned), devised by a Jesuit Father, displayed a shroud net. This event occurred in Lisbon, Portugal, in 1709, 245 years ago. Most of these shroud nets were used both as a hold-down method during inflation and as a harness to connect the payload to the balloon. Some had supplementary lines attached to the shroud net at the equator, specifically for hold-down use during inflation.

The U. S. Army balloons of 30 years ago employed shroud nets, principally of cotton. They weighed approximately 2-1/2 pounds per 1,000 cubic feet of gas capacity. The shroud was initially used to secure the balloon during the inflation. The diamond laced net terminated in individual strands on the ground which were tied into sandbags. At the completion of the inflation the lines and sandbags were drawn in and tied to the payload.

In addition, the Army employed shroud nets for inflating balloons which were flown without nets. "In netless balloons it is necessary to use a net for the inflation until the balloon is sufficiently full to allow the sandbags to be attached to the suspension ropes. To allow the net to be

taken off when inflated, it is usually cut on one side and laced. The lacing employed is similar to a chain stitch, which can be pulled out from below, and the net is free to slide off the balloon.¹ It will be seen later that this shroud release system is similar to the device used at Holloman Air Development Center, although this chapter had not been previously noted.

In the Summer of 1947, New York University flew several spherical (as opposed to teardrop) polyethylene balloons at Holloman Air Force Base. Every other balloon seam (nine total) was modified with an eyelet for attaching a bridle rigging to the balloon at 30° below its equator. This bridle or semi-shroud could be employed as a hold-down line system prior to tying in the payload.

In 1947 and 1948, New York University flew at Holloman Air Force Base, an extensible J-2000 neoprene balloon within a shroud. The shroud, made of nylon, is the closest in configuration to the new development. It was used both for inflation and to limit the expansion of the neoprene balloon during flight. The author was involved in the launching of one of these flights in 1948, but recalls that the J-2000 (grams) was so small that the advantages of the shroud for inflation purposes were not apparent.

Today, small canvas shrouds are occasionally used for inflating radiosonde neoprene balloons during heavy surface winds.

Summing up, therefore, it may be seen that:

The basic idea of a shroud is as old as balloons themselves. Some of the first (net) shrouds were used specifically as a solution to our present vertical inflation problem.

Fabric shrouds had recently been introduced but not for non-extensible balloons.

Consequently, like many other "new" techniques, we have finally devised something which is an innovation as a whole but the parts of which have had innumerable predecessors.

B. Design of the Shroud:

1. Shroud Cap No. 1 was designed in June 1953. Originally, it was intended to enclose the bubble of a completed 1,500-pound gross inflation within a hemispherical shroud (cap) surmounting a truncated right circular inverted cone, terminating at the top of the cylindrical reefing sleeve. The total configuration was designed but only the hemispherical cap was constructed because:

First, a satisfactory release system had not yet been devised. The cap could conceivably be pulled off without a formal release system but not the cone.

1

"Free and Captive Balloons", Upson and Chandler, Ronald Press Co., N.Y. 1934

Secondly, it was desired that the effect of the fabric on the balloon material be investigated before the same fabric was used for the cone.

Third, preliminary tests on miniature shroud caps indicated that perhaps the hemisphere alone would be sufficient for proper control of the balloon.

2. Design Specifications:

a. The fabric selected was plain weave, mercerized cotton airplane cloth, Stock No. 1900-170000-441. The tensile strength was 100 pounds per linear inch on the Dillon Universal Tester. The cost was \$.64 per square yard. Three samples, each one square yard, of this material were washed and dried. Average shrinkage was 4% in warp and 2% in filling. Density was 4.00 ounce per square yard. Adequate supplies of airplane cloth in bolts a yard wide were on hand. (This determined the maximum width of the hemispherical gores.)

b. Volume Determination:

Gross inflation in pounds lift - 1500 pounds

Lift of helium - Grade A or .06957 pounds per cubic foot

Maximum temperature (which provides a maximum volume) -
38° C or 311° Absolute.

Minimum pressure (which provides a maximum volume) -
25.390 inches of mercury. (As extracted from Holloman Air Force Base climatological data)

The desired maximum volume is equal to - $\frac{\text{gross inflation}}{\text{minimum lift}}$

The minimum lift is equal to -

$\frac{.06953 \text{ lbs/ft}^3 \times 273^\circ \text{ A.} \times 25.39 \text{ in. Hg (minimum HAFB pressure)}}{29.92 \text{ in. Hg } 311^\circ \text{ A. (maximum HAFB temperature)}}$

which is equal to - .05183 lb/cubic foot.

The desired volume is equal to $\frac{1500 \text{ pounds gross inflation}}{.05183 \text{ lb/cubic foot}}$

or 28,941 cubic feet

The volume of the hemisphere plus truncated cone system is

hemisphere

plus

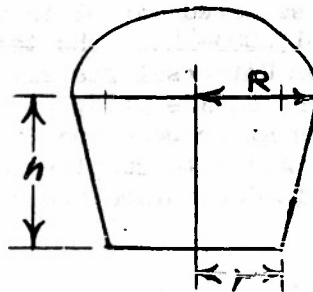
truncated cone

$$\frac{2}{3} \pi R^3$$

$$\frac{\pi}{3} h (R^2 + Rr + r^2)$$

$$\text{Volume System} = \frac{\pi}{3} (2R^3 + h R^2 + h Rr + h r^2)$$

$$= 28,941 \text{ cubic feet}$$



In order to determine R, the radius of the cap, r, the radius of the reefer was selected as 5 feet. The average diameter of the reefers have only been about two feet, but it was originally intended to have a tapered reefer with the shroud. h was selected as equal to R, the shape being approximately a natural one.

With r equal to five feet and h equal to R, the equation shown above is easily solved.

$$= 28,941 \text{ cubic feet} = \frac{\pi}{3} (2R^3 + R^3 + 5R^2 + 25R)$$

$$R = 20.2 \text{ ft.}$$

To allow for shrinkage this figure was adjusted to 20.6 feet. Because the bolts of airplane cloth available were only three feet in width, it was decided to make the shroud cap out of 45 gores, each maximum width being 34-1/2 inches. This left 3/4 inch on each side for sewing purposes. Because of sewing limitations, it was decided to have a flat top rather than a peak. The minimum gore width, consequently, was designed as 4.9 inches. The resulting loss in volume is only 2.7 cubic feet.

Eight 2,900 pound test OD webbing hold-down lines, each 200 feet in length, were attached to the shroud perimeter.

3. Design of Shroud Cap No. 2:

In December 1953, a new shroud cap, to be constructed of plain weave nylon duck cloth, was designed. Cost of the material was \$1.43 per yard. The Stock No. is 7100-425500-134. In accordance with ASTM grab test method, the 1/64th-inch thick, OD nylon fabric, averaged 474 pounds in warp

and 447 pounds test in filling. The density of the material is 7.25 Oz/square yard. Other specific changes from shroud cap No. 1 were:

Gross inflation - 2,000 pounds

Helium lift used - .0692 pounds/cubic foot, for Grade D helium

The volumetric system was solved with r , the radius of the top reefer, equal to 2 feet.

The radius for this cap was computed to be 22.9 feet. The construction of the cap was completed in February 1954, with 48 gores, each 3 feet in maximum width.

Each individual gore was 36 feet in length and 68.7 square feet in area. The total area of the hemispherical cap is 3,295 square feet.

To date, two airplane cloth shrouds and one nylon shroud have been constructed by the Special Parachute Unit of Holloman Air Development Center. (A duplicate of the first canvas shroud was constructed for Air Force Cambridge Research Center. They have already employed it on some test flights.) Each type required a total of 550 yards of material and an estimated utilization of 300 man-hours. The cost of material alone was \$800 for the nylon shroud, and \$350 for the airplane cloth shroud.

4. Modifications and development of supplementary devices:

Initially the hold-down lines were sewed directly into the edges of the cap. After the first few tests they were made detachable.

In October 1953, four of the hold-down lines were modified so that each forked into three branches before hooking into the cap perimeter (See Figure 2). Commencing with Test No. 10, (See Page 14), 27 October 1953, only these four lines were employed. The technique has been successful, thus limiting the manpower required on such a flight and considerably simplifying the entire process. In addition, each hold-down man is supplied the line in a canvas bag, which he wears over his shoulder during the reeling out period (See Figure 3).

The first unlacing type reefer employed with the shroud was constructed of airplane cloth. It was found to be subject to tears and rips and was finally replaced with a nylon reefer. Considerable trouble was afforded by upper portions of the reefer during inflation which had already been unlaced. This was handily solved by tying the top of the reefer to a line which was connected to the shroud perimeter (See Figure 4).

Even in a perfect calm the inflation tube is often restricted dangerously by the harness lines at the base of the balloon. A simple aluminum tube lined with polyethylene was constructed to fit between the harness and the balloon during inflation.

C. Description of the tests:

Test No. 1 - 16 June 1953 - Dummy canvas shroud, 10 feet square, weighing 8 pounds with 4 hold-down lines. General Mills' 20-foot diameter, "Rocket" balloon (cell with a conical apex for rapid ascent). Surface winds - 3 knots with gusts to 6 knots.

Purpose of test - To determine effectiveness of the shroud for controlling twisting and buffeting during vertical inflation.

Results - The cell was inflated to the vertical position with the shroud in position and a 10-inch red polyethylene inflation tube employed as the reefer (See Figure 5). The balloon was successfully maintained in the vertical position without twisting the inflation tube for 15 minutes. At the end of this period a 6 knot gust picked up one side of the canvas and literally pushed the balloon out from under the cap. Without the shroud cap, the balloon commenced to twist and was displaced as much as 40 degrees from the vertical.

Test No. 2 - 31 July 1953 - Dummy shroud, 20 feet square, hold-down line at each corner. General Mills' 20-foot diameter, "Rocket" balloon. Surface winds - 7 knots with gusts to 12 knots.

Purpose of test - To test a shroud which covered the hemisphere of the balloon bubble (as opposed to the top 30° in the first shroud) in fresh surface winds.

Results - On four successive trials, the shroud slipped off the balloon before the latter could be walked to the vertical position. The failure appeared to be just as much due to the configurations of the shroud and balloon as to the gusty wind. The "Rocket" balloon had a conical top rather than the usual spherical shape. The dummy shroud did not possess the three dimensional design required for a snug fit.

Test No. 3 - 11 September 1953 - Shroud Cap No. 1 with 8 hold-down lines. Winzen 72.8-foot diameter balloon. Surface winds - 0-2 knots.

Purpose of test - To make a general evaluation of this first full size shroud cap.

Results - The test was extremely successful and most of the handling procedures still employed with the shroud evolved from this test. Although various formal cap releases were in preparation, in the test, the cap was simply pulled off (See Figure 6). No observable damage was inflicted on the top of the balloon but the frictional effect of the sliding canvas, in addition to the dragging hold-down lines, appeared unfavorable.

Test No. 4 - 16 September 1953 - First operational test - HAFB 168. Shroud Cap No. 1 with 8 hold-down lines. Winzen 72.8-foot diameter balloon. Surface winds - 0-2 knots. Payload - 972 pounds. Total duration - 3.7 hours.

Purpose of test - To determine whether the shroud cap with the informal type release, employed on Test No. 3, was inflicting damage to the balloon.

Results - The inflation was successful but the cap release appeared to abrade the top of the balloon even more severely than on the previous test. The balloon performance, however, indicated that no large scale damage had been inflicted. In fact, the overall descent rate after attaining peak was 530 ft/hour. Experience with Covered Wagon flights indicate that polyethylene balloons rubbing against cloth may suffer small magnitude damage which will only be evidenced during long duration flights.

All the tests to date, with shroud cap No. 1, are summarized in the table on page 14.

D. Evolution of the Shroud Cap Release System:

1. System No. 1:

This method was employed on Tests 1, 2, 3, 4, and 19. No modifications were employed. The actual 2900-pound test hold-down tapes were used. After completion of the inflation the hold-down men on the up-wind side walked their lines around toward the down-wind side to prevent them from dragging over the top of the bubble during release. The men on the down-wind side ran away from the balloon with the lines until the cap was dragged off. If there was wind of 3 knots or more this process was an easy one for the cap would tend to sail. In a lighter wind, however, the balloon would often "cup" under the cap and the cell would actually be displaced from the vertical before the cap was released.

Despite the apparent unfavorable abrasive qualities of this technique, no obvious damage was ever detected in the 5 tests. For short flights this system appears plausible, in fact, there appears to be more danger of damage to the shroud than the balloon. If adopted for constant use, something stronger than airplane cloth should be employed. In addition, it would be necessary to develop a method of removing all the lines save those on the down-wind side, prior to release.

2. System No. 2:

This system was employed on tests 5 and 6. Nylon cord was run from the cap perimeter up over the apex and down to a point on the perimeter 180° from the initial point. Two of these lines running perpendicular to one another were installed.

When ready for release both release lines are pulled until all of the material on the opposite side (hatched area above figure) is bunched up near the balloon apex. Then both the standard hold-down lines and the two release lines are pulled to slip off the entire cap.

This system appeared to be somewhat superior to the first but similar to the latter, it resulted in the slack hold-down lines being drawn over the balloon. This fault could be eliminated as explained previously.

However, the actual release of the cap was still not as smooth as desired and on both tests some tipping of the balloon was necessary to effect the release.

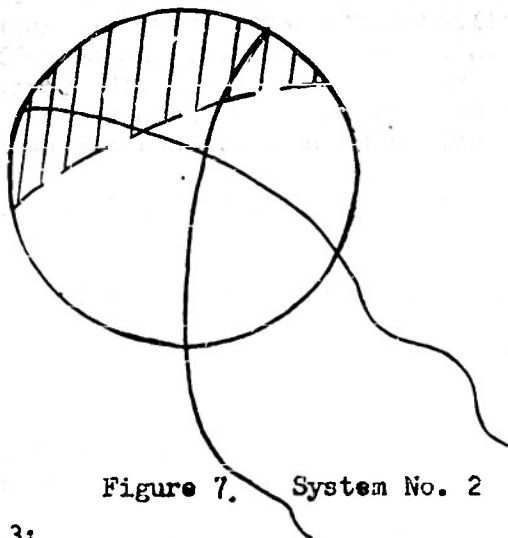


Figure 7. System No. 2

3. System No. 3:

A slit was made in the shroud cap from the perimeter to the apex. A line was attached on either side of the split at the perimeter. The two lines at the split were pulled so that each corner of the split was displaced 90°. The shroud, consequently, gathered into the same hatched area illustrated in Figure 7. The remainder of the release was completed exactly as in System No. 2.

This system appeared to work much smoother than any of the previous methods. However, it demanded considerable material strength at the apex where the split terminated. On the second tests a rip developed at this point.

4. System No. 4:

This system was identical to that of the previous system save that the split was lengthened so that it encompassed $3/4$ of the shroud. It was only employed on one test.

5. System No. 5:

This system was first employed on Test No. 9, 15 October 1953, and is still being used at the present time (February 1954). The cap is split into halves. Cotton loops are sewn on to one side of the split and matching grommets cut on the other side. A 500-pound test tubular nylon line is employed to thread the loops after they have been pulled through the grommets. A type of chain stitch is used. The lacing starts at the apex with a separate line stitched down to each perimeter.

Moderate tension is retained on the hold-down lines during the splitting process. As the halves separate the hold-down men run from the balloon as fast as possible in order to prevent the fabric from draping over the payload.

The split cap technique has been demonstrated to be a superior one. Using it, there has been one possible flight of eight days with an unballasted 116-foot diameter balloon. Such a performance could only be obtained from a balloon which had been subjected to a bare minimum of abrasive effects.

The only element of this technique which requires further attention is the unlacing system. Thus far, the chain stitch has not failed to unlace during any of the tests. The time required for the unlacing is too long, however, for the fast action that is required in winds over 7 knots. In addition the leverage is awkward, the people pulling the release lines having to run from the balloon for a considerable distance. A recent test was performed on 5 March 1954 involving the use of an unlacing system comprised of simple loops (Figure 8). The results were highly promising and this technique will be re-employed on future tests.

III. DISCUSSION OF RESULTS

A. Test Summary:

In 16 tests, as of 5 February 1954, 17 out of 18 inflations were completed with one failure being caused by the shroud cap. In 15 out of 18 inflation attempts, the combined shroud cap unlacing reefer-boom system resulted in complete successes.

The success of the shroud cap has forestalled the original plan to develop a complete balloon shroud. The next step in this system development is concerned with the nylon shroud cap now being fabricated. It is planned to attempt to hold the balloon close to the ground, during the entire inflation, with the use of winches. This technique should afford greater protection from the wind and less trouble during the unreefing process. (Which was involved in all three of the failures.) After inflation the balloon will be raised to the vertical position and released in the normal fashion. With such a technique the balloon may be held down, if necessary, until wind conditions become more favorable. If successful, this development should increase inflation wind capabilities to the 10 knot category.

B. Comparison With Other Launching Systems:

1. The Launch Platform - The use of this early balloon inflation technique has been modernized for heavy loads by some constant level balloon organizations. In general, this system which involves the release of the bubble from its normal position invokes lateral motion of the payload which cannot be tolerated with the fragile, heavy load involved in certain balloon programs. It is also felt that with slight modifications of the present shroud system, a launch from the vertical position can be achieved in heavier winds than with the launch platform release.

A second launch platform system involves the unrolling of the balloon through the launch arms, after completion of inflation, until the cell is completely vertical. This technique would appear to have many virtues, all of which could be duplicated by the proposed nylon shroud technique. Furthermore, the latter should exceed the wind inflation capabilities of the launch platform system as far as opposition to twisting of the bubble by the wind is concerned.

2. The Covered Wagon - The present model does not have the volumetric capacity for heavy load inflations (maximum gross inflation is approximately 700 pounds). In addition, the covered wagon has demonstrated unfavorable abrasive effects on inflations which approach the maximum. Equally important is the fact that a launch from this vehicle once again demands lateral movement of the payload upon release.

IV. CONCLUSIONS

The present shroud system has increased vertical inflation capabilities to such an extent that the actual launching techniques now have to be extended. The inflation system at this time appears to demand little skill in handling with winds up to 5 knots. In an earlier test an attempt in an inflation during 7 knots was unsuccessful. In a more recent test however, with the launching personnel demonstrating noticeably increased skill, a 7 knot inflation was successfully negotiated (Figure 9). (It must be realized that the wind values quoted are as determined at the surface or 20 feet above the surface. The actual speeds encountered at an elevation equal to the height of the center of mass of the balloon bubble will usually be greater.)

Most of the balloons which were inflated with the shroud system demonstrated better than average altitude performance. This may be due to the larger masses of lifting gas and more rugged balloon material employed with the heavy loads. However, it does serve to indicate that the cap at least does not inflict more damage than the covered wagon or launch platform. The two long duration flights of 1-1/2 and 3 days demonstrated better performance than similar experience with maximum inflations in the covered wagon.

The present release systems for both the reefer and cap are adequate, but can be improved.

Four hold-down lines manned by able personnel appears to be considerably more advantageous than eight hold-down lines manned by less able people. In addition, it is easier to direct the four men and the whole operation appears cleaner.

A wind of approximately 4 knots or more will cup under the shroud and cause considerable sail effect when the bubble is relatively small. This effect can be thwarted by keeping the bubble close to the ground in the initial stages and by designing the shroud for a snug fit for the maximum intended gross inflation. At Holloman Air Force Base, the bubble and the

cap are often held down inside the covered wagon launcher (without the top laced) during the initial stages of inflation.

V. RECOMMENDATIONS

Development of the nylon shroud cap technique should be diligently pursued. Not only should it increase the capability to inflate in surface winds, but it would simplify reefer operations during inflation. Tests should be made to determine if the abrasive effects of the nylon upon the polyethylene are more detrimental than that of the airplane canvas.

As improved shroud cap technique increases the inflation capability in fresh surface winds, the actual launching techniques should also be advanced to meet these capabilities. Originally, the shroud was developed to meet the specific requirements of the Balloon Program TD No. 5182-H1 which normally will restrict its launches to the most favorable conditions. The evolving versatility of the shroud cap system, however, makes it worth while to proceed in the direction of ever increasing wind capabilities. This appears especially necessary when considering the increasing number of balloon projects involving heavy loads. Many of these projects must be pursued on a time basis, thus requiring launches under fresh wind conditions.

Even with fragile loads, where it is normally planned to launch in the most favorable conditions, it is sometimes necessary to possess the ability to withstand a wind of 5 knots or more. Especially in the summer with heavy cumulus clouds over the mountains, a long calm will be momentarily interrupted by a gust of wind which could be fatal to a launch system geared only to light winds.

Quicker and more positive releases for both the reefer and shroud cap should be investigated. Instantaneous releases would be highly desirable. The most beneficial reefer would actually be one which is not released until the payload has cleared the ground. This technique assures a minimum sail effect during take-off.

As this system assumes increasing versatility with the gradual improvement of all the components, its adaption to light loads should be pursued.

SUMMARY OF TESTS WITH SHROUD CAP NO. 1

<u>TEST NO.</u>	<u>DATE</u>	<u>BALLOON DIAMETER</u>	<u>SURFACE WINDS</u>	<u>PAYLOAD WEIGHT</u>	<u>INFLATION RESULTS</u>	<u>CAUSE OF FAILURE</u>	<u>FLIGHT DURATION</u>
3	11 Sep 53	72.8 ft.	0-2 knots		Success		Ground Test
4	16 Sep 53	72.8 ft.	0-2 knots	972 lbs.	Success		3.7 hours
5	29 Sep 53	72.8 ft.	1-3.7 knots	1,012 lbs.	Success		6.2 hours
6	2 Oct 53	90 ft.	0-2 knots	1,246 lbs.	Success		1.1 hours
7	20 Oct 53	90 ft.	0-3 knots	1,200 lbs.	Success		0
8	14 Oct 53	61 ft.	2-5 knots		Success		Ground Test
9	15 Oct 53	72.8 ft.	1-3 knots	1,042 lbs.	Success		35 hours (plus)
10	27 Oct 53	116 ft.	0-2 knots	1,002 lbs.	Success		3 days
11	10 Nov 53	72.8 ft.	Calm	960 lbs	Failure	Reef	0
12	13 Nov 53	72.8 ft.	0-3 knots	960 lbs.	Success		2.5 hours
13	7 Dec 53	94 ft.	Calm	1,100 lbs.	Success		0.5 hours
14	9 Dec 53	116 ft.	Calm	1,100 lbs.	Success		0
15	11 Dec 53	90 ft.	2-7 knots	1,100 lbs.	Failure	Cap, Reef	0
16	17 Dec 53	116 ft.	0-2 knots	1,100 lbs.	Failure	Reef	0
17	19 Jan 54	72.8 ft.	2-6 knots	1,100 lbs.	Success		0
18	22 Jan 54	72.8 ft.	0-2 knots	1,129 lbs.	Success		3.5 hours
19	28 Jan 54	92.5 ft.	3-7 knots	800 lbs.	Success		3.7 hours
20	5 Feb 54	92.5 ft.	Calm	800 lbs.	Success		2.7 hours

APPENDIX I

INFLATION OPERATIONAL PROCEDURE OUTLINE

1. The balloon is tied into the boom of a 40-foot crane with the apex of the cell down wind. An electrical squib is inserted in the tie-down line in order that the balloon may eventually be released without danger to personnel.
2. The cap should be laced the day before the flight with the split parallel to the wind direction. The balloon is layed out on the ground inside the cap so that the apexes are in juxtaposition.
3. Before the reefing cloth is laced, the inflation tube is partially filled with lifting gas in order to unravel any twists.
4. If the top of the reefer does not extend up to the perimeter of the shroud cap an extra section of canvas is employed for this exposed section of the balloon. When inflation is initiated one man contains this section in order to prevent gas from feeding back into the reefer. This procedure is required only for the few minutes before the cap is lifted by the balloon.
5. As the inflation commences, one man grasps the tangent apexes not relinquishing until the bubble ascends above his reach. Two other men kneel on top of the shroud on either side of the bubble in order to restrict its volume while resting on the ground.
6. In a few minutes, the gas will be filling back toward the reefer. At this point, all four men leave their initial stations and grasp the perimeter of the shroud where their (previously) assigned hold-down lines are hooked in.
7. As the shroud rises, the hold down men slip on the bags containing the rolled line and continue to let the shroud rise as it will. A fifth man

operates the line which unlaces the reefers.

8. The shrouded bubble is walked toward the boom as it continues to rise until it is vertical over the boom.

9. Procedures for handling the lines during winds of 5 knots or more can best be learned by experience rather than description. The most successful technique is to have alert men on the lines who during a wind continuously look up at the shroud and normally make their own adjustments in tension and positioning. This has been found to be superior to the originally planned technique of having one man direct all the adjustments.

10. The reefing sleeve is removed first after the inflation is terminated. Although some sail effect will result, if there is any wind, the balloon may be maintained vertically or almost vertically by proper control with the shroud cap.

11. Actual release of the shroud cap is described on Page 10. A wind shift can be compensated for by manipulation of the boom.

12. For a step by step photographic series of the procedures, see Figure 10 (A-B).

APPENDIX II

SAMPLE TIMING TABLES FOR SHROUD OPERATIONS

Date - 16 September 1953

Balloon Size - 72.8 feet

Gross Inflation - 1400 pounds

<u>EVENT</u>	<u>TIME MST</u>	<u>WIND SPEED(mph at 15 ft. elevation)</u>
1. Layout is initiated	0500	
2. Layout is completed	0545	
3. Inflation is initiated	0558	2.2
4. Balloon becomes vertical	0609	3.6
5. Inflation is completed	0624	1.7
6. Shroud is released	0643	1.5
7. Take-off	0648	1.3

Date - 29 September 1953

Balloon Size - 72.8 feet

Gross Inflation - 1450 pounds

1. Layout is initiated	0650
2. Layout is completed	0720
3. Inflation is commenced	0725
4. Balloon becomes vertical	0735
5. Helium trailers are switched	0740-56
6. Inflation is completed	0807
7. Shroud is released	0812
8. Launch	0815

FIGURE 1. SHROUD CAP TECHNIQUES

3/4 MILLION CUBIC FOOT BALLOON



FIGURE 2. FORKED HOLD-DOWN LINES



79516 HADC 7 DEC 53
SHROUD CAP RIGGING
MX 1450B
W/O 53-6367

FIGURE 3. HOLD-DOWN LINEMAN



19476 HADG 7 DEC 53 MX 1450
HOLD-DOWN MAN-ON SHROUD CAP LONE
HAFB 183 W/O 53-6867

FIGURE 4. REEFER TIED TO CAP PERIMETER



1446 HADC -193.28 JAN 54 MX1277
92.5 DIAM BALLON W.O. 154-110

FIGURE 5. TEST NO. 1
WITH DUMMY CANVAS SHROUD



SECOND MOCK OF TEST MX-1450B

FIGURE 6. FIRST SHROUD RELEASE METHOD

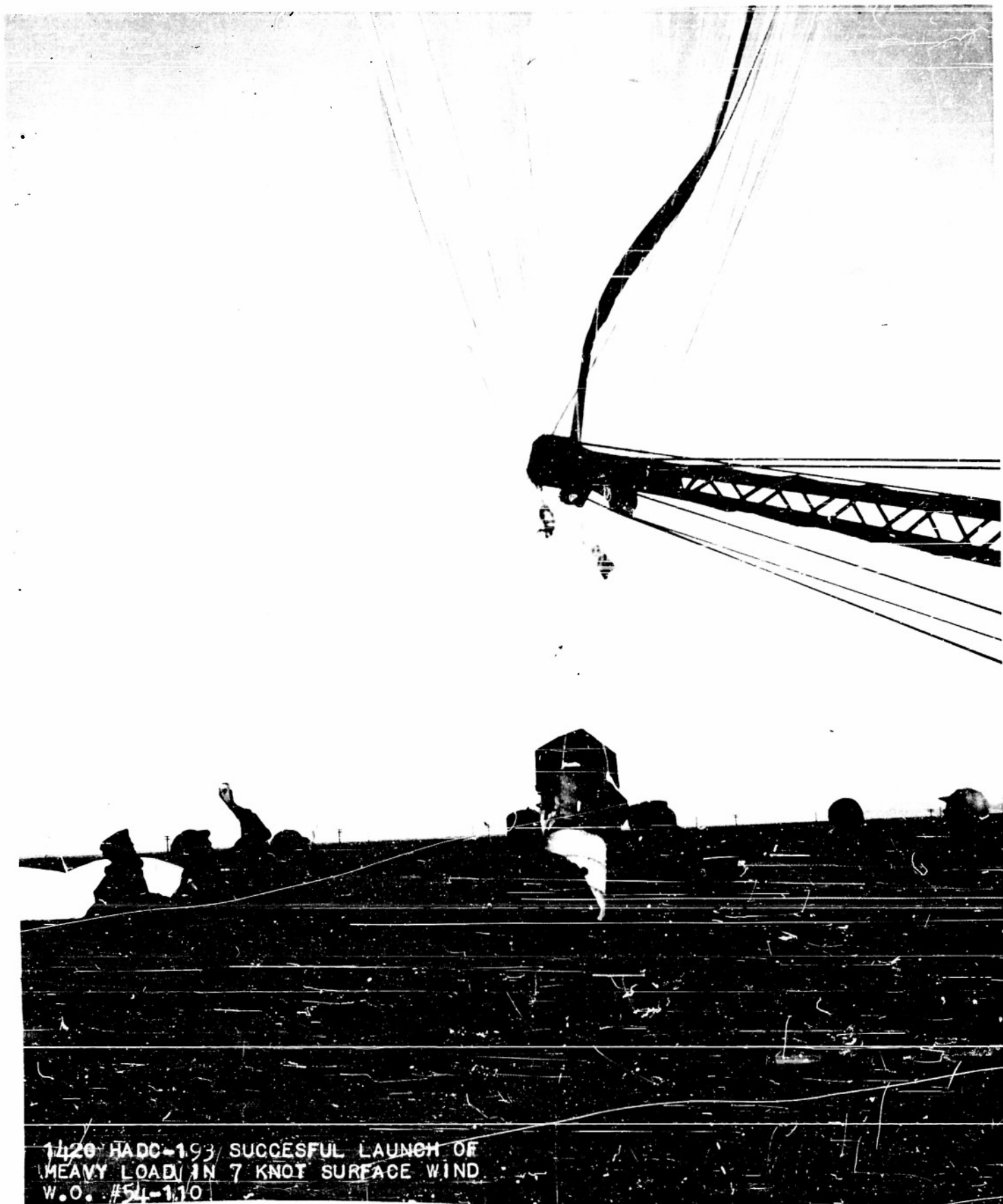


1401 G-HADC 11 SEP 53 RELEASE
OF SHROUD MX 1450B

FIGURE 8. LACING ON SHROUD CAP




FIGURE 9. 800 POUND LOAD
LAUNCHED IN 7 KNOT WIND ON A 92.5 FT. DIAMETER BALLOON



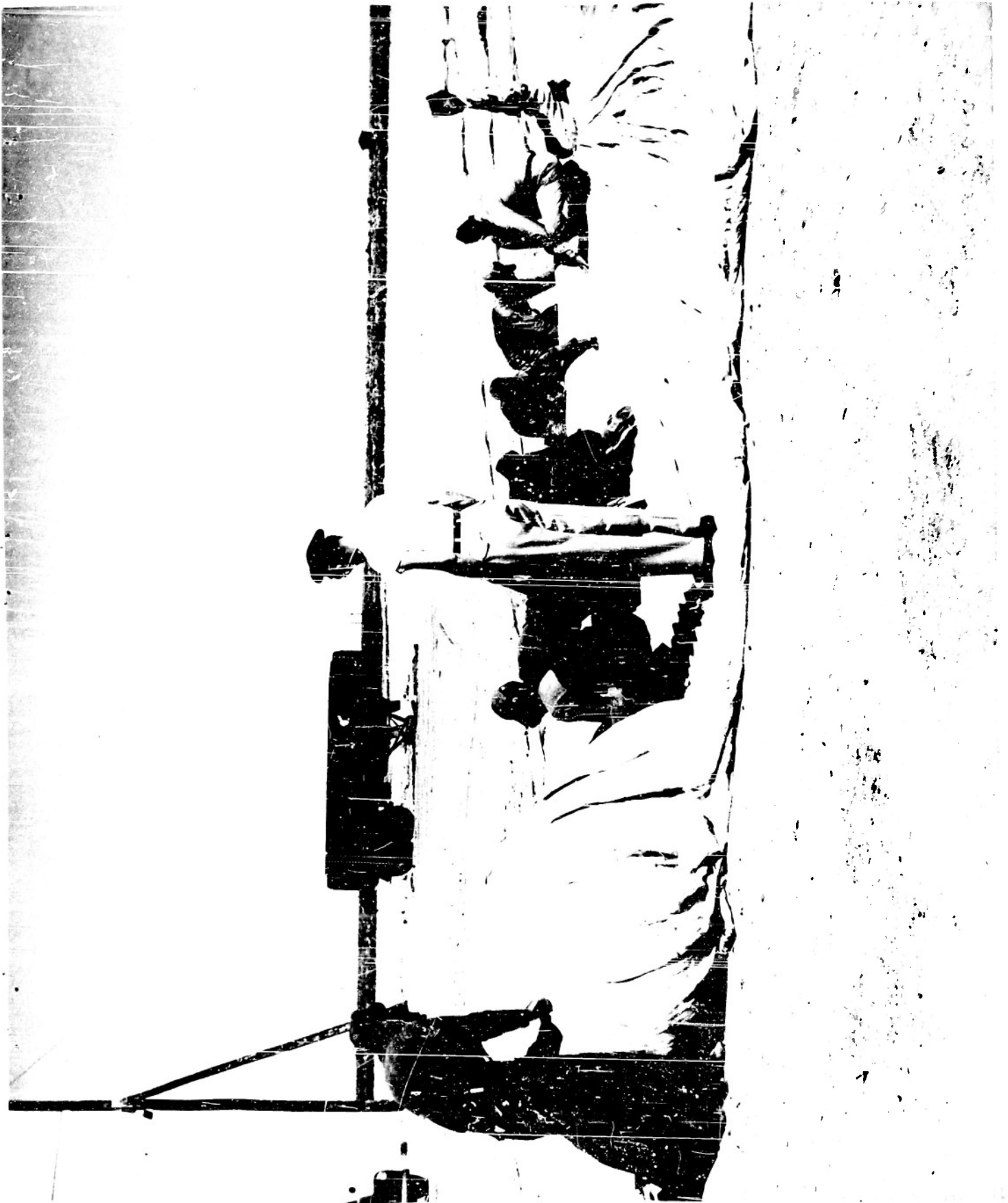
1420 HADC-193 SUCCESSFUL LAUNCH OF
HEAVY LOAD IN 7 KNOT SURFACE WIND
W.O. #54-110

FIGURE 10 (A-H). SHROUD INFLATION, STEP BY STEP

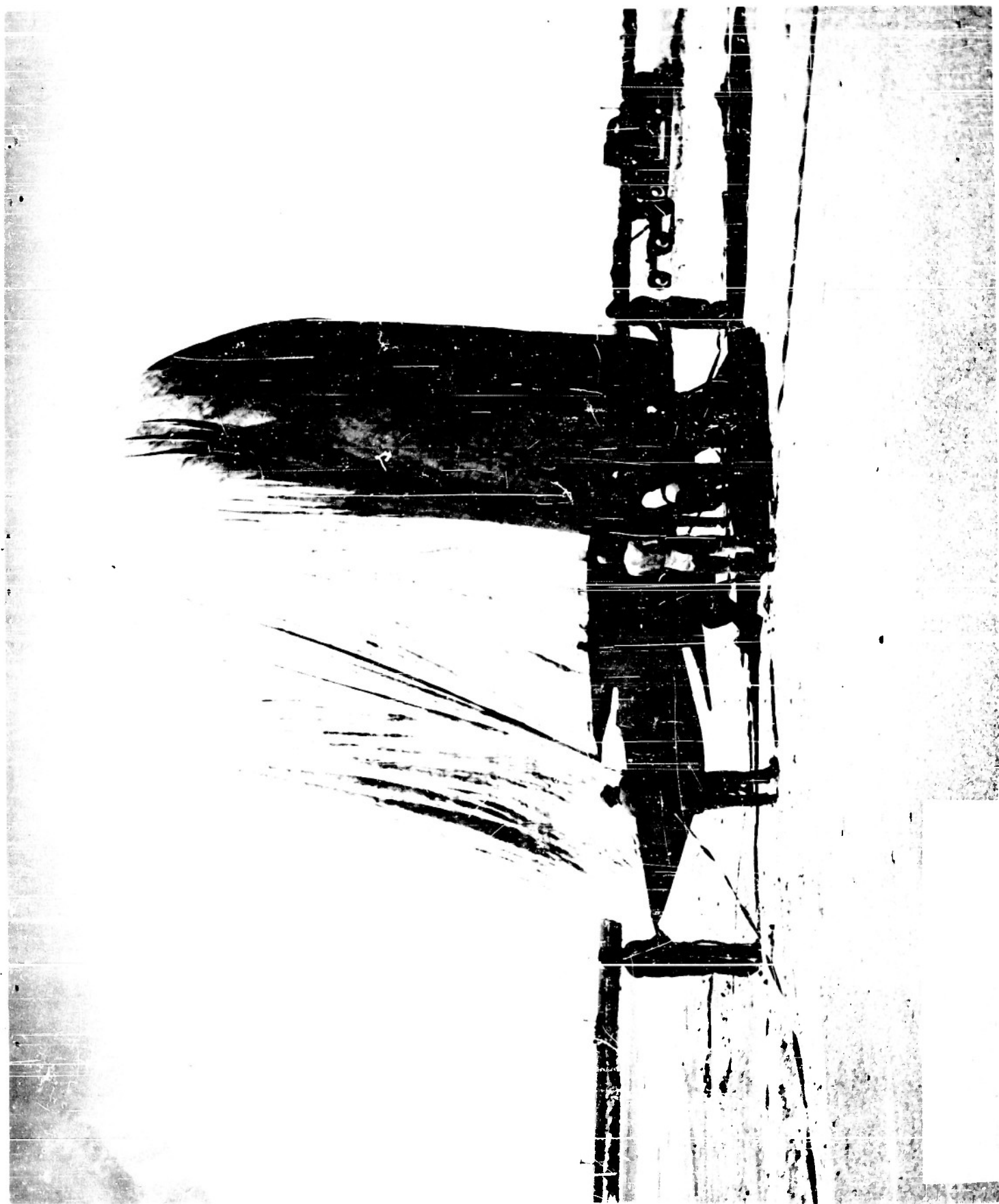


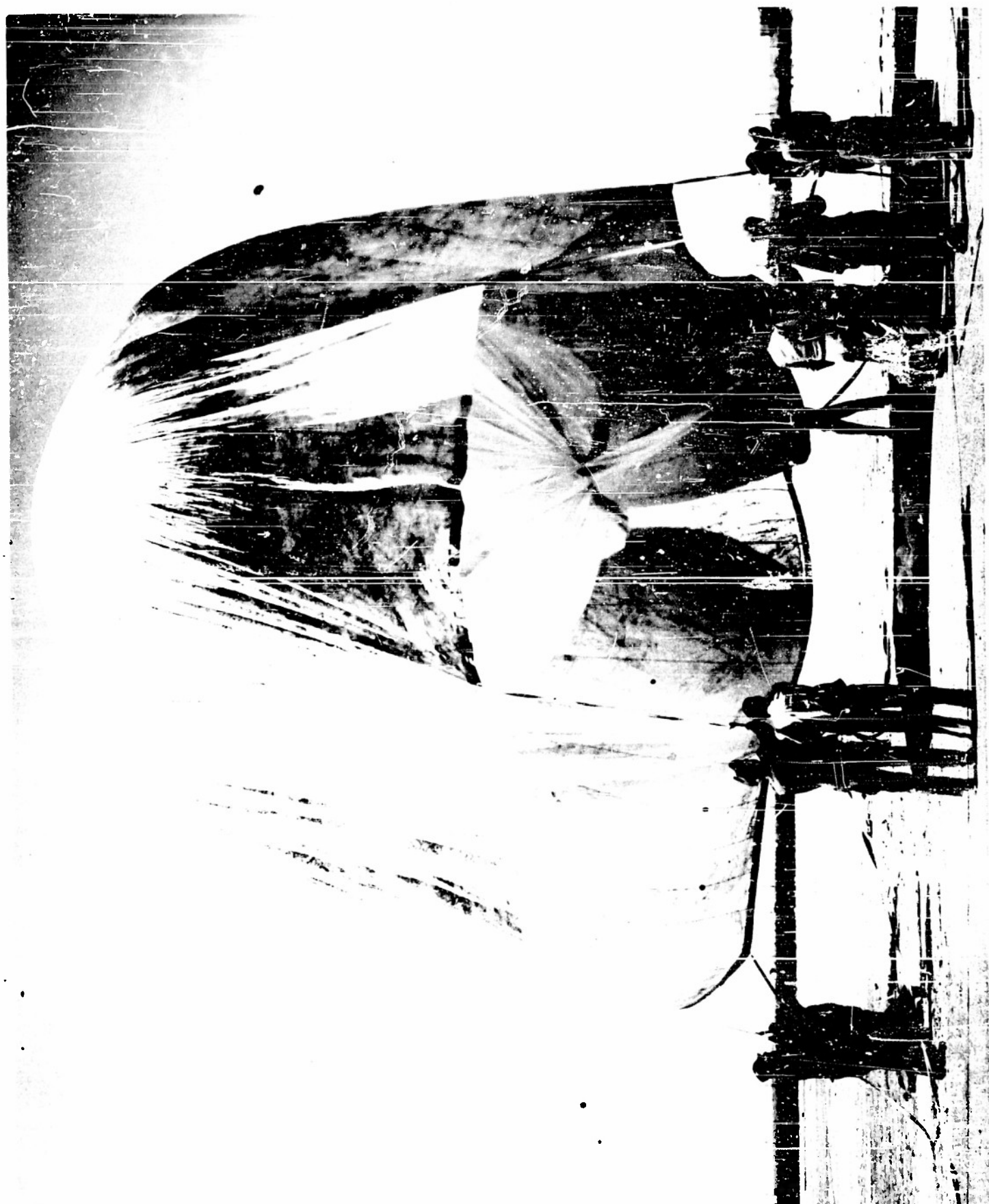
1392 G HADC 11 SEP 53 INITIAL
LAYOUT FOR SHROUD INFLATION
MX 1450B





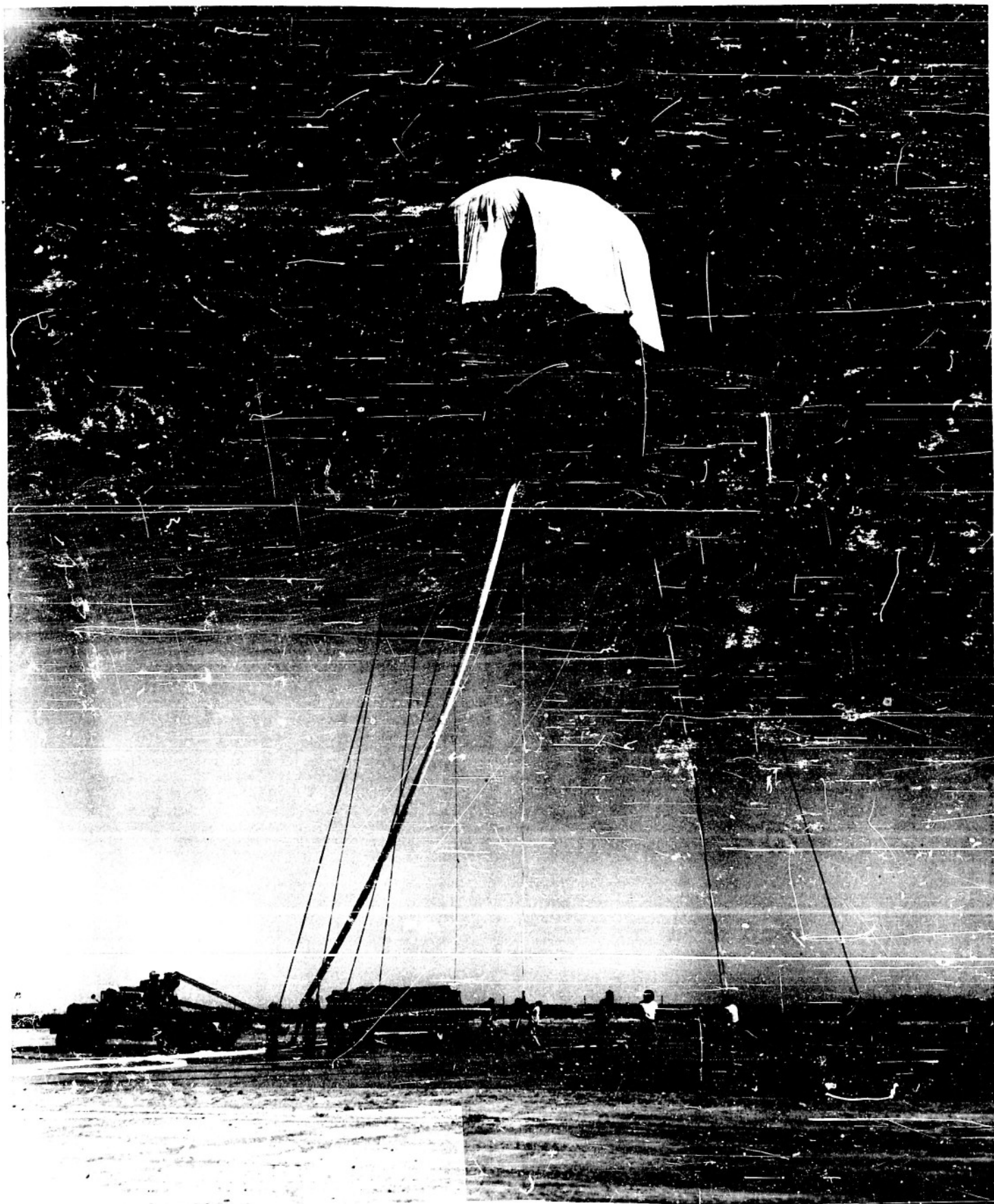








1956 6 HADC 11 SEP
INFLATION TEST MX



DISTRIBUTION FOR THIS REPORT

Copy No.

Executive Office
 Directorate of Research and Development
 Deputy Chief of Staff, Development
 Department of the Air Force
 Washington 25, D. C.

1 - 3

Commander
 Air Research and Development Command
 Attn: RDTOT
 P. O. Box 1395
 Baltimore 3, Maryland

4 - 5

Commander
 Wright Air Development Center
 Attn: WCRDB-4
 Attn: WCOL-2
 Attn: WCOSR
 Wright-Patterson Air Force Base
 Ohio

6
 7
 8

Commander
 Air Force Cambridge Research Center
 Attn: CRHT
 Cambridge, Massachusetts

9

Armed Services Technical Information Agency
 Documents Service Center
 U. B. Building
 Dayton 2, Ohio

10 - 14

Commander
 Holloman Air Development Center
 Attn: HDOTI
 Attn: Navy Liaison Officer
 Attn: HDTS
 Attn: HDTA
 Holloman Air Force Base
 New Mexico

15
 16
 17 - 36
 37

Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

AD

39440

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by

DOCUMENT SERVICE CENTER

KNOTT BUILDING, DAYTON, 2, OHIO

UNCLASSIFIED